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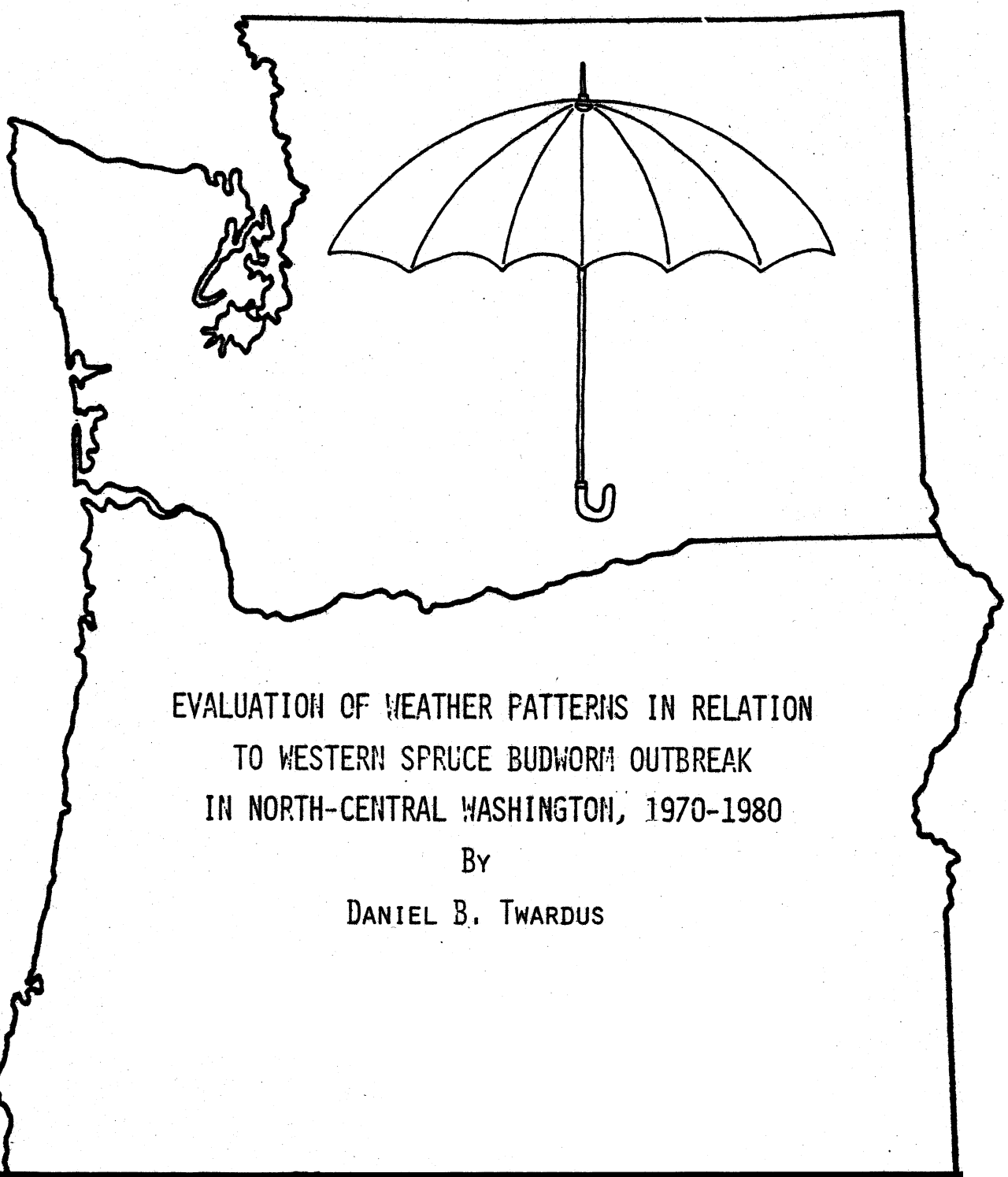

EVALUATION OF WEATHER PATTERNS IN RELATION TO WESTERN SPRUCE BUDWORM OUTBREAK IN NORTH-CENTRAL WASHINGTON, 1970-1980

By

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Evaluation of Weather Patterns in Relation to Western Spruce Budworm Outbreak in North-Central Washington, 1970-1980

Introduction

During the 1970 forest insect and disease aerial survey, 240 spruce budworm-defoliated acres were observed in the Wolf Creek Drainage of the Okanogan National Forest. As shown in Figure 1, by 1972 the defoliated acreage had exploded to 167,480 acres on both the Wenatchee and Okanogan National Forests.

This dramatic increase is due to a number of factors such as absence of sufficient parasites and predators, abundant and susceptible host, and weather conditions conducive to budworm feeding and development. Wellington et al (1950) concluded that forest stand composition is the basis of budworm outbreak, but that weather is the immediate cause of rapid release and outbreak.

The effects of weather patterns upon release of eastern budworm populations has been investigated by Greenbank (1963). The conditions ideal for budworm development based upon this work are plenty of sunlight and dry weather, specifically during the spring. Hard et al (1980) found similar conditions conducive to western spruce budworm outbreak in Montana and northern Idaho.

Tussock moth outbreak/release has also been related to weather patterns. Lessard (1974) found a significant correlation between below normal precipitation for the month of July in Washington and Oregon and subsequent tussock moth outbreak.

Evaluating the effect of climatic release upon the 1970's north-central Washington budworm outbreak is the objective of this report.

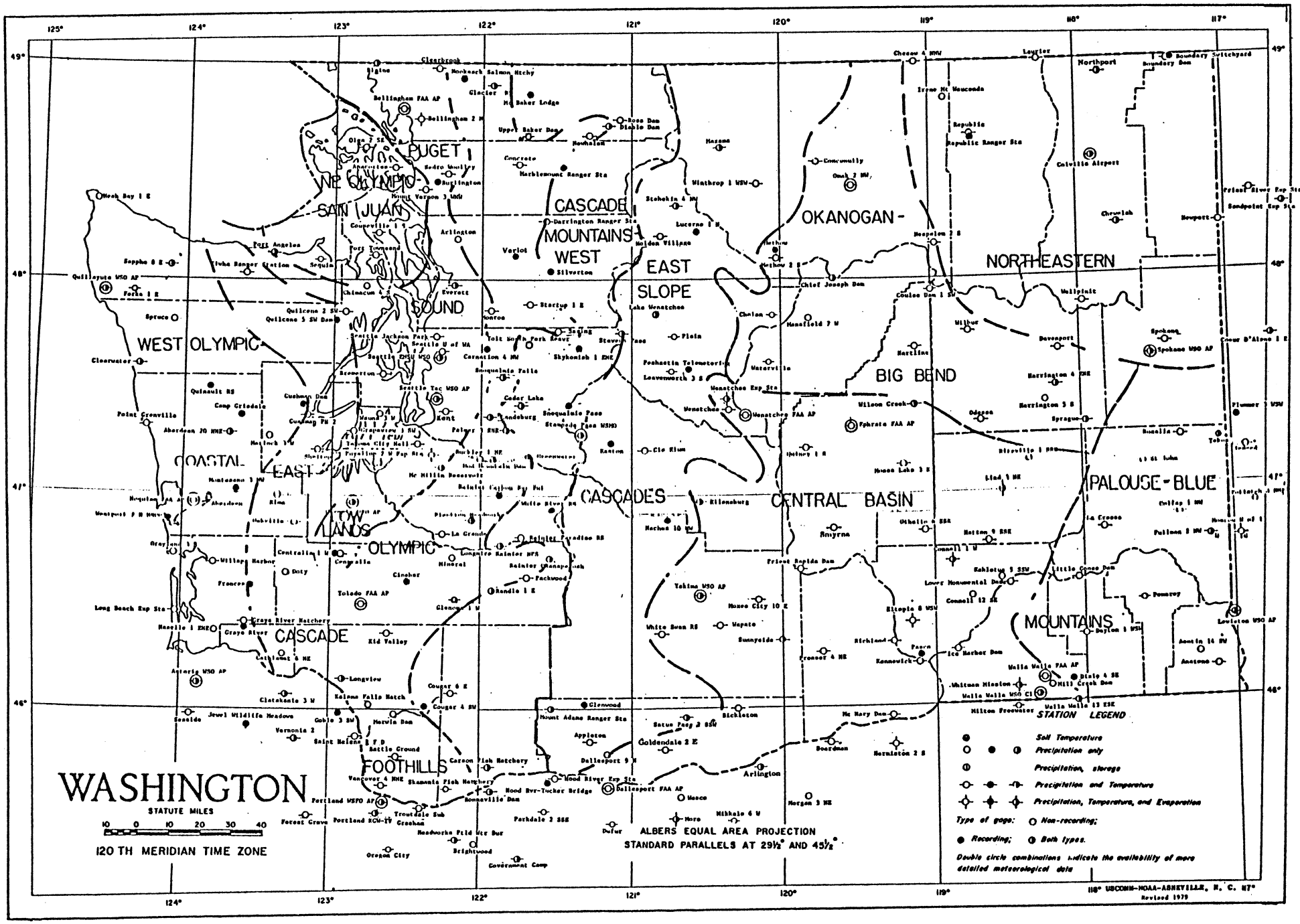

WASHINGTON
STATUTE MILES
10 0 10 20 30 40
120 TH MERIDIAN TIME ZONE
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS AT 29½° AND 45½°
PUGET SOUND
NW OLYMPIC
SAN JUAN
CASCADE MOUNTAINS WEST
CASCADE MOUNTAINS EAST SLOPE
OKANOGAN - NORTHEASTERN
WEST OLYMPIC
COASTAL - EAST
OLYMPIC
CASCADES
CENTRAL BASIN
BIG BEND
PALOUSE - BLUE MOUNTAINS
FOOTHILLS
STATION LEGEND
Soil Temperature
Precipitation only
Precipitation, storage
Precipitation and Temperature
Precipitation, Temperature, and Evaporation
Type of gage: Non-recording; Recording; Both types.
Double circle combinations indicate the availability of more detailed meteorological data
USCOMM-NOAA-ASHEVILLE, N. C. Revised 1979

Figure 1.--Aerial survey records show those defoliated acres for geographic zones in north-central Washington*

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
East slope (includes Twisp, Winthrop RD & all Wenatchee RD)	240	18,260	167,480	202,440	442,974	394,700	835,680	552,180	131,120	199,930	68,850
Okanogan Big Bend (includes Conconully RD)	0	0	0	0	0	0	3,800	1,310	1,860	28,500	10,270
Northeast (includes the Tonasket RD)	0	0	0	0	0	0	120	0	8,750	22,650	0

*Chemical control operations occurred during 1976 and 1977 in the East Slope zone.

Methods

Weather records were obtained from the Climatological Data Records of the U.S. Department of Commerce for stations distributed throughout three geographic zones in north-central Washington. The zones are the East Slope of the Cascades with stations in Leavenworth, Mazama, Stehekin, and Winthrop; the Okanogan Big Bend with stations in Chelan, Conconully, and Methow; and the Northeastern Zone with stations in Chesaw, Chewalah, Colville, and Republic. The Wenatchee National Forest and the Twisp and Winthrop Ranger Districts of the Okanogan National Forest are in the East Slope zone. The Conconully Ranger District lies within the Okanogan Big Bend Zone, and the Tonasket Ranger District lies within the Northeastern Zone.

Using the work of Hard et al (1980) and Lessard (1974) as a basis, two weather variables were summarized for each zone; mean maximum temperatures for May, June, and July, and number of days with measurable precipitation for the same months. Taken together, these variables can serve to index overcast, low temperature conditions which may directly affect budworm development and feeding behavior. In addition, mean minimum temperatures were summarized for the same months.

Extent and intensity of the budworm outbreak was quantified through use of aerial survey and defoliator "beating" plot records. Both are relatively inaccurate records. Aerial survey requires considerable defoliation to be present before it is visible from the air. This means that some population level exists below which budworm buildup is not detected. For "beating" plots, timing is critical. If the plots are done too early or too late, the larval numbers obtained are not comparable to other years.

Insufficient data exists for detailed statistical analysis. Chemical control operations within the East Slope Zone during 1976 and 1977 prohibit use of data beyond those years. Within the Northeastern and Okanogan Big Bend Zones, defoliation was not observed until 1976. Outbreaks in these zones have never reached extensive proportions.

Analysis consists of a comparison of gross weather trends with changes in defoliated acres surveyed and defoliator "beating" plot records.

Results

Tables 1-3 show weather type and defoliation trend for the 3 geographic zones. The years of interest for each zone are those immediately preceding the population buildup. If weather patterns are important in triggering outbreaks, then the years preceding a discernable buildup may be more critical than weather patterns occurring during the outbreak. The years of interest, then, are 1973-75 for the Okanogan Big Bend (Conconully) Zone, and Northeastern (Tonasket) Zones, and 1968-70 for the East Slope of the Cascades Zone.

The east slope is where most of the budworm outbreak developed during the early 1970's. For this zone, the years previous to the outbreak were characterized by abnormally warm, dry weather conditions (Figures 2 and 3). Table 4 shows in the 3 years previous to outbreak detection (1968-1970) the frequency of measurable rainfall was less than half of that during the previous 3 years (1965-67). This indicates that weather had changed (become drier) in the 3 years leading up to the outbreak in comparison to prior years. For this zone, budworm defoliation was first observed in 1970. Defoliator beating plots were not established until 1972. By that time, population buildup had occurred, indeed; over 100,000 acres of defoliation was observed from aerial survey.

For the Okanogan Big Bend and the Northeastern Zones, defoliation did not become apparent until 1976. (Figure 1). The years of interest for these zones are 1973-1975. In the Northeastern Zone, the pattern of warm, dry weather immediately preceding population buildup is apparent (Table 3, Figures 4 and 5). Significant changes in beating plot counts, however, did not occur until 1977. In the Okanogan Big Bend Zone, the pattern of warm, dry weather immediately preceding outbreak detection is less apparent. As shown in Table 4, however, frequency of measurable precipitation was lower during the 3 years prior to population buildup than during the previous 3 years. This again indicates that weather patterns had changed (become drier) in the years leading up to outbreak detection in comparison to prior years. Unlike the northeastern zone, this zone's defoliation beating plot records show a definite increasing trend during the dry years.

Figures 8 and 9 illustrate mean minimum temperatures for the 3 geographic zones. Combining the minimum and maximum temperature records indicates that warm days and warm nights were characteristic of the Northeastern and East Slope Zones just prior to outbreak detection. The Okanogan Big Bend Zone experienced cool days but warm nights just prior to outbreak detection.

Conclusions

A weather pattern of warm, dry days preceded budworm outbreak detection in two out of three areas in north-central Washington. The third area had dry conditions and abnormally warm nights immediately preceding outbreak detection.

These weather patterns, though not being the only factor involved with budworm outbreak, undoubtedly play a critical role. Monitoring weather patterns in relation to defoliator activity can contribute to the ability to predict budworm outbreaks. This is especially important in evaluating the significance of results from pest detection surveys.

For some insects, such as the balsam woolly aphid, warm, dry weather enables more than one generation per year to develop (Greenbank, 1970). In the case of budworm or tussock moth, these same spring weather conditions insure rapid larval development. The less time it takes for larval development, the less time larvae are exposed to parasites and predators.

All zones experienced cool and wet weather during the spring of 1980. This should have a detrimental effect upon budworm populations in the zones. The effect of one season's weather, however, is probably more important in relation to its influence upon population release than upon established populations. Aerial survey of spruce budworm in Washington during 1980 reflects the close association between current weather and budworm populations. The cool, wet 1980 spring weather made detection of budworm feeding impossible in many areas. Though feeding was present, host buds had flushed well in advance of larval development. Feeding, then, was masked by the abundance of untouched host foliage. This accounts for the considerable reduction in defoliated acreage shown for 1980 in Figure 1.

Most likely, and as this report indicates, more than one season of warm, dry weather is necessary for population increase. Similiarly, more than one season of cool, wet weather is probably required for population decrease.

Table 1.--Weather and budworm trends for the East Slope of the Cascades 1969-1975. Defoliation was first recorded during 1970.

Year	Weather type[1/] (May, June, July)	DEFOLIATION TREND		
		Direction	Numerical[2/]	Beating plot[3/]
1969	Warm and dry		0	-
1970	Warm and dry	+	0	-
1971	Cool and dry	+	76.1	-
1972	Cool and wet	+	9.17	19.8
1973	Warm and dry	+	1.21	14.1
1974	Cool and dry	+	2.19	
5.9				
1975	Cool and dry		.89	21.4

Footnotes for tables 1-3:

1/ Weather type is relative to 11 and 21 year means.

2/ Numerical ratings are present year's defoliated acreage divided by the acreage the year before.

3/ Beating plot counts are average number of WSBW larvae per 80 plots.

4/ Beating plot counts are average number of WSBW larvae per 8 plots.

Table 2.--Weather and budworm trends for the Okanogan Big Bend Zone, 1973-1979. Defoliation was first recorded during 1976.

Year	Weather type[1/] (May, June, July)	DEFOLIATION TREND		
		Direction	Numerical[2/]	Beating plot[4/]
1973	Warm and dry			.75
1974	Cool and dry	+	0	2.3
1975	Cool and dry	+	0	3.5
1976	Cool and dry	+	0	22.3
1977	Cool and wet	+	.34	62.0
1978	Warm and wet	+	1.42	22.0
1979	Warm and dry	+	15.3	84.7
1980	Cool and wet			88.3

Table 3.--Weather and budworm trends for the Northeastern Zone, 1973-1980. Defoliation was first recorded during 1976.

Year	Weather type[1] (May, June, July)	DEFOLIATION TREND		
		Direction	Numerical[2]	Beating plot[4]
1973	Warm and dry		0	0
1974	Warm and dry		0	.5
1975	Warm and dry		0	.3
1976	Cool and wet	+	0	.1
1977	Cool and wet	+	0	5.7
1978	Cool and wet	+	1.42	.12
1979	Warm and dry	+	2.6	20.5
1980	Cool and wet			3.3

Table 4.--Average total number of days with precipitation of .1 or more inches during May, June, and July.

Okanogan Big Bend: (defoliation first observed 1976)	1970 - 1.6 days	
	1971 - 6.6 days	X = 6.3 days
	1972 - 10.6 days	
	1973 - 1.5 days	
	1974 - 5.4 days	X = 3.5 days
	1975 - 3.7 days	
East Slope Zone: (defoliation first observed 1976)	1965 - 5.5 days	
	1966 - 6.8 days	X = 6.5 days
	1967 - 4.8 days	
	1968 - 4.0 days	
	1969 - 3.8 days	X = 3.0 days
	1970 - 1.1 days	
Northeastern Zone: (defoliation first observed 1976)	1970 - 7.5 days	
	1971 - 17.1 days	X = 13.0 days
	1972 - 14.3 days	
	1973 - 6.1 days	
	1974 - 10.6 days	X = 9.5 days
	1975 - 11.8 days	

FIGURE 2.--MEAN MAXIMUM TEMPERATURE

LEAVENWORTH, MAZAMA, STEHEKIN, WINTHROP (EAST SLOPE)

1967 - 1980

(MAY, JUNE, JULY)

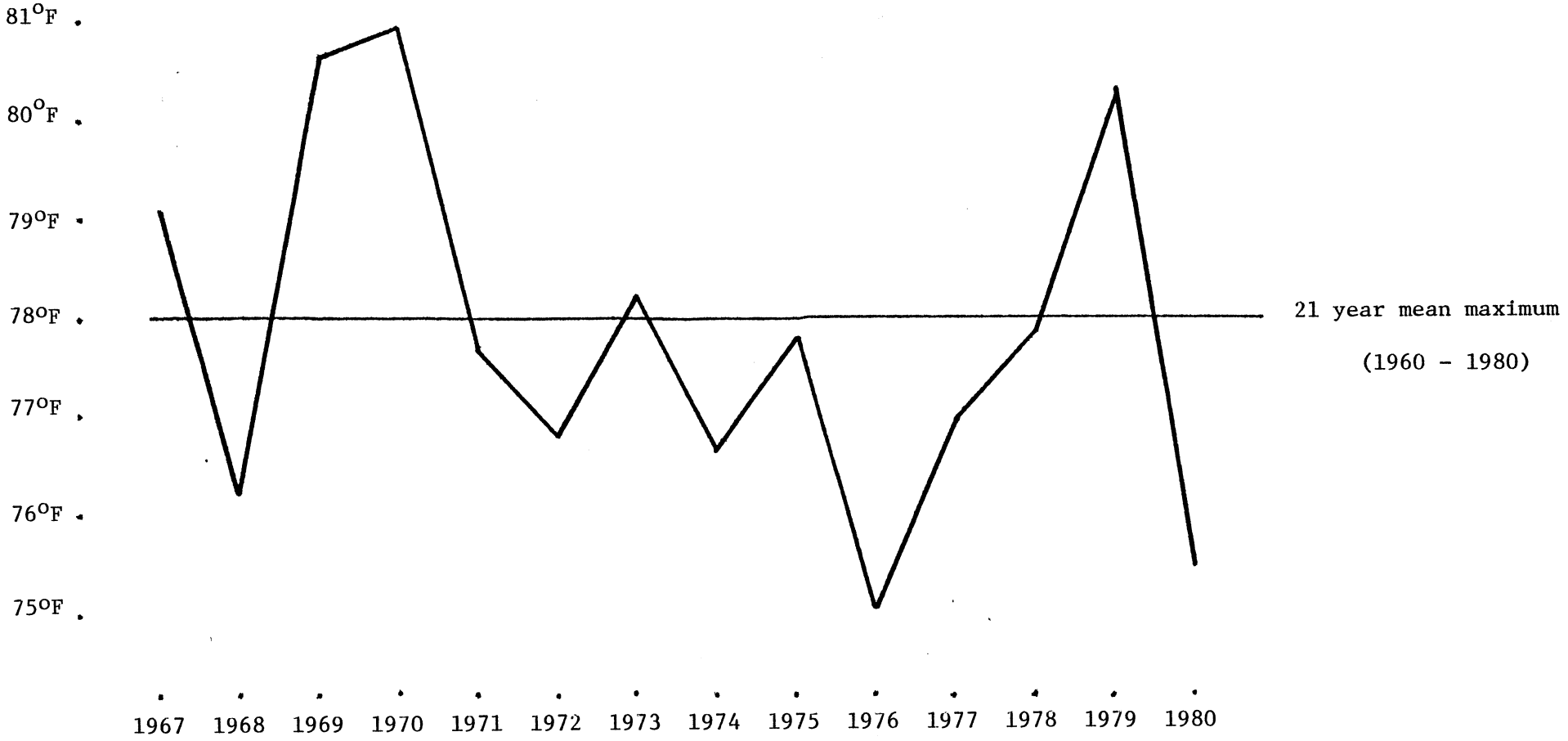


FIGURE 3.--AVERAGE NUMBER OF DAYS OF .1 INCHES OR MORE PRECIPITATION

LEAVENWORTH, MAZAMA, STEHEKIN, WINTHROP (EAST SLOPE)

MAY, JUNE, JULY

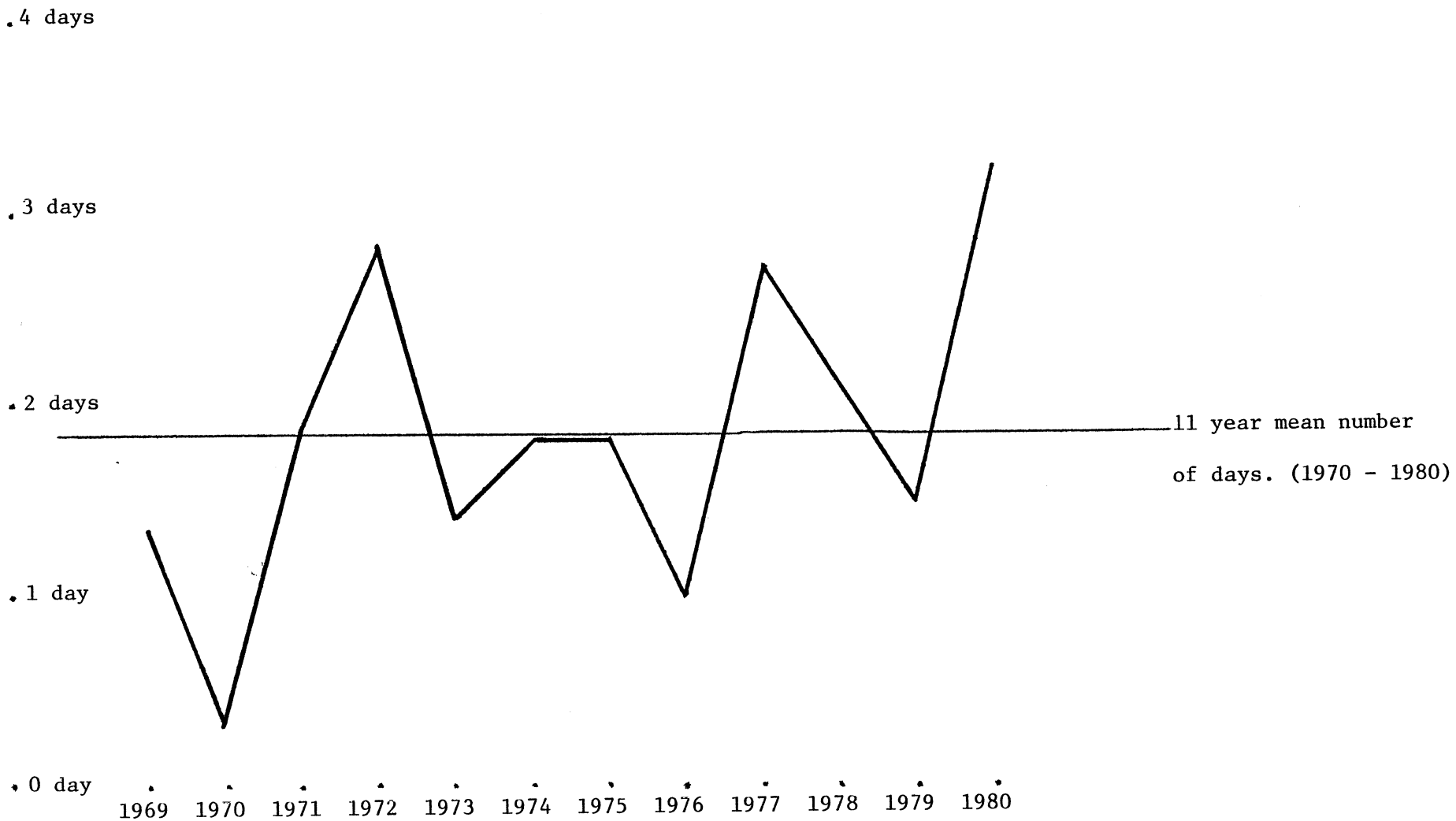


FIGURE 4.--MEAN MAXIMUM TEMPERATURE

CHESAW, CHEWELAH, COLVILLE, REPUBLIC (NORTHEASTERN)

1970 - 1980

(MAY, JUNE, JULY)

FIGURE 5.--AVERAGE NUMBER OF DAYS OF .1 INCHES OR MORE PRECIPITATION

(MAY, JUNE, JULY) CHESAW, CHEWELAH, COLVILLE, REPUBLIC (NORTHEASTERN)

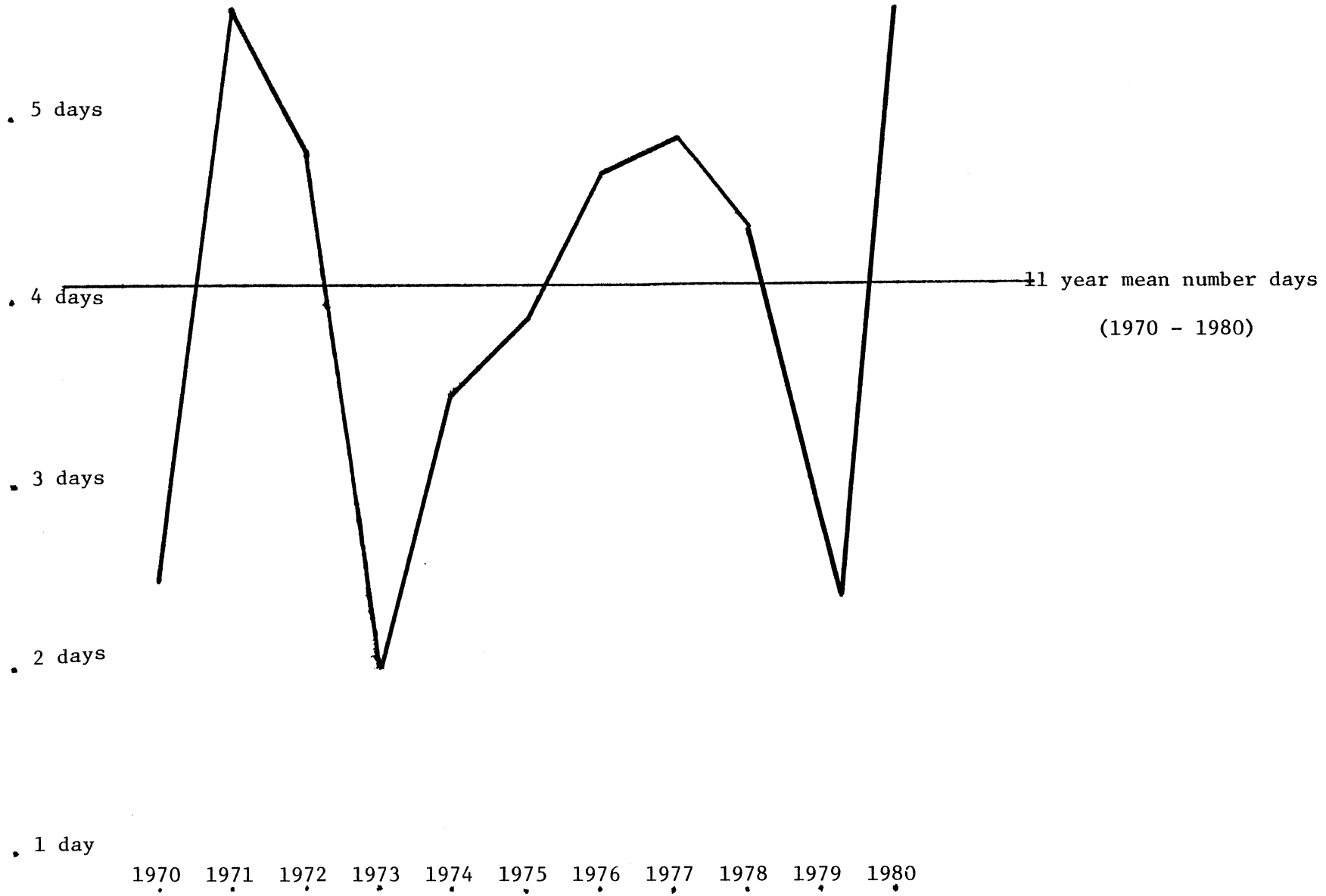


FIGURE 6.--MEAN MAXIMUM TEMPERATURE

CONCONULLY, METHOW, CHELAN (OKANOGAN BIG BEND)

1970 - 1980

(MAY, JUNE, JULY)

FIGURE 7.--AVERAGE NUMBER OF DAYS OF .1 INCHES OR MORE PRECIPITATION

(MAY, JUNE, JULY) CONCONULLY, METHOW, CHELAN (OKANOGAN BIG BEND)

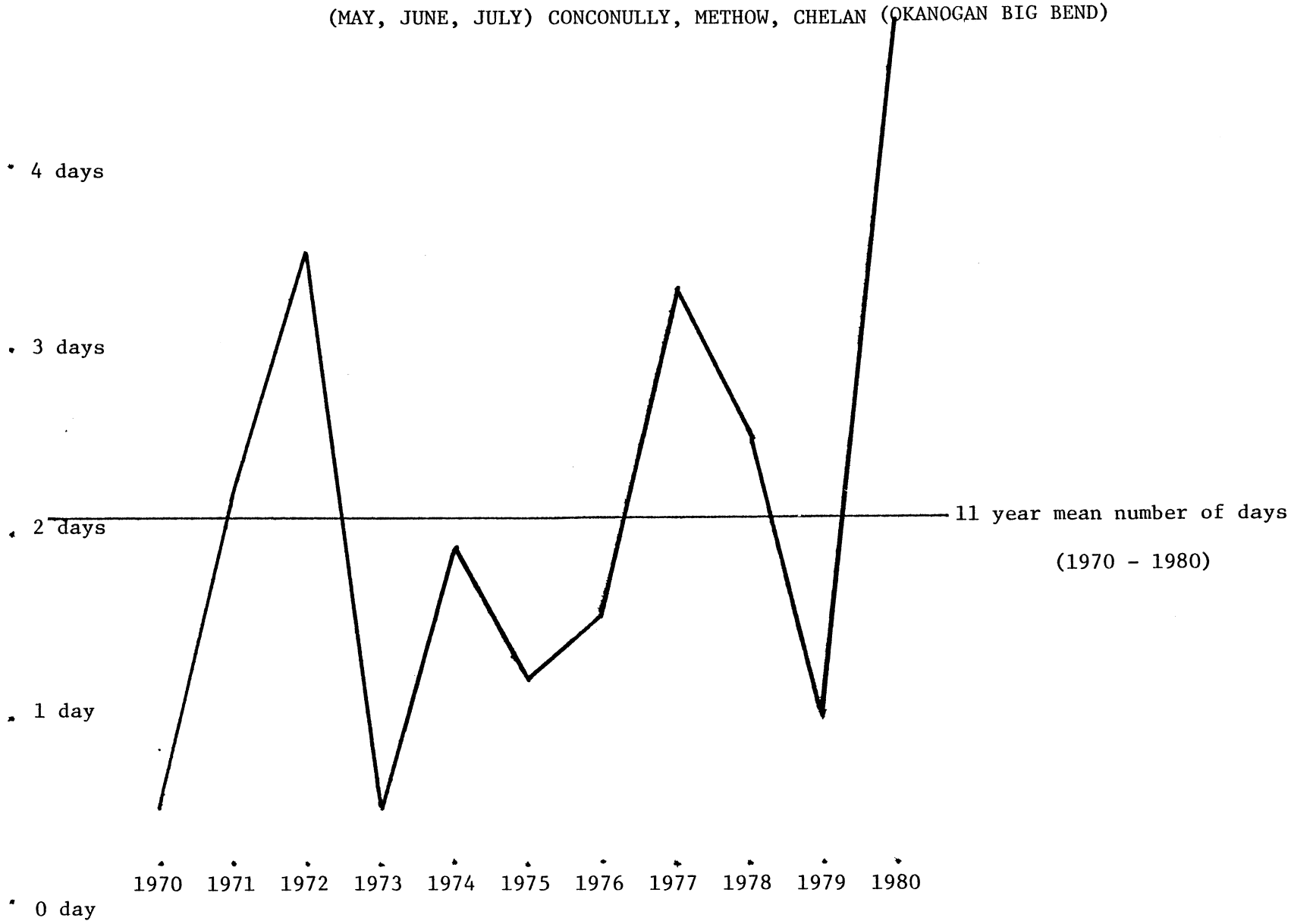


FIGURE 8.--AVERAGE MINIMUM TEMPERATURE

EAST SLOPE

1960 - 1980

(MAY, JUNE, JULY)

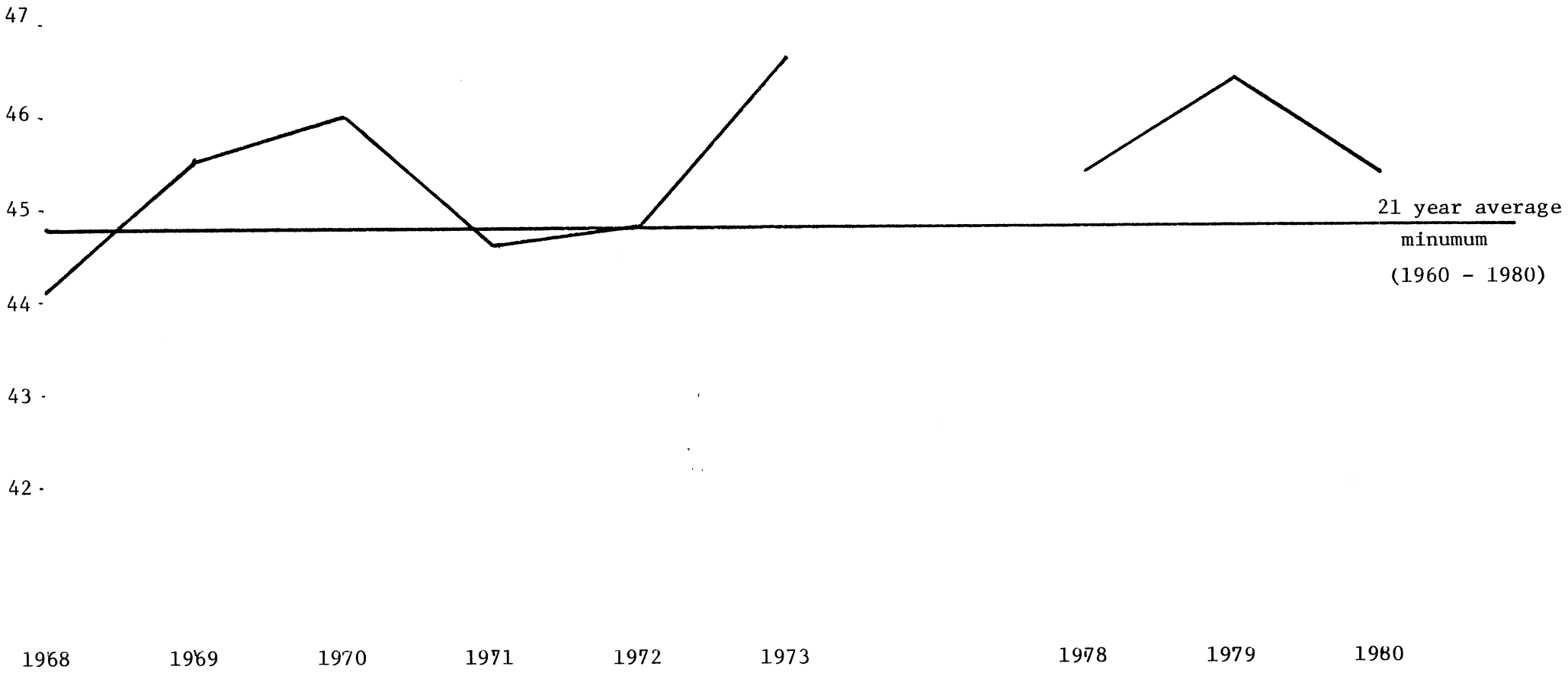


FIGURE 9.--MEAN MINIMUM TEMPERATURE

NORTHEASTERN AREA

1970 - 1980

(MAY, JUNE, JULY)

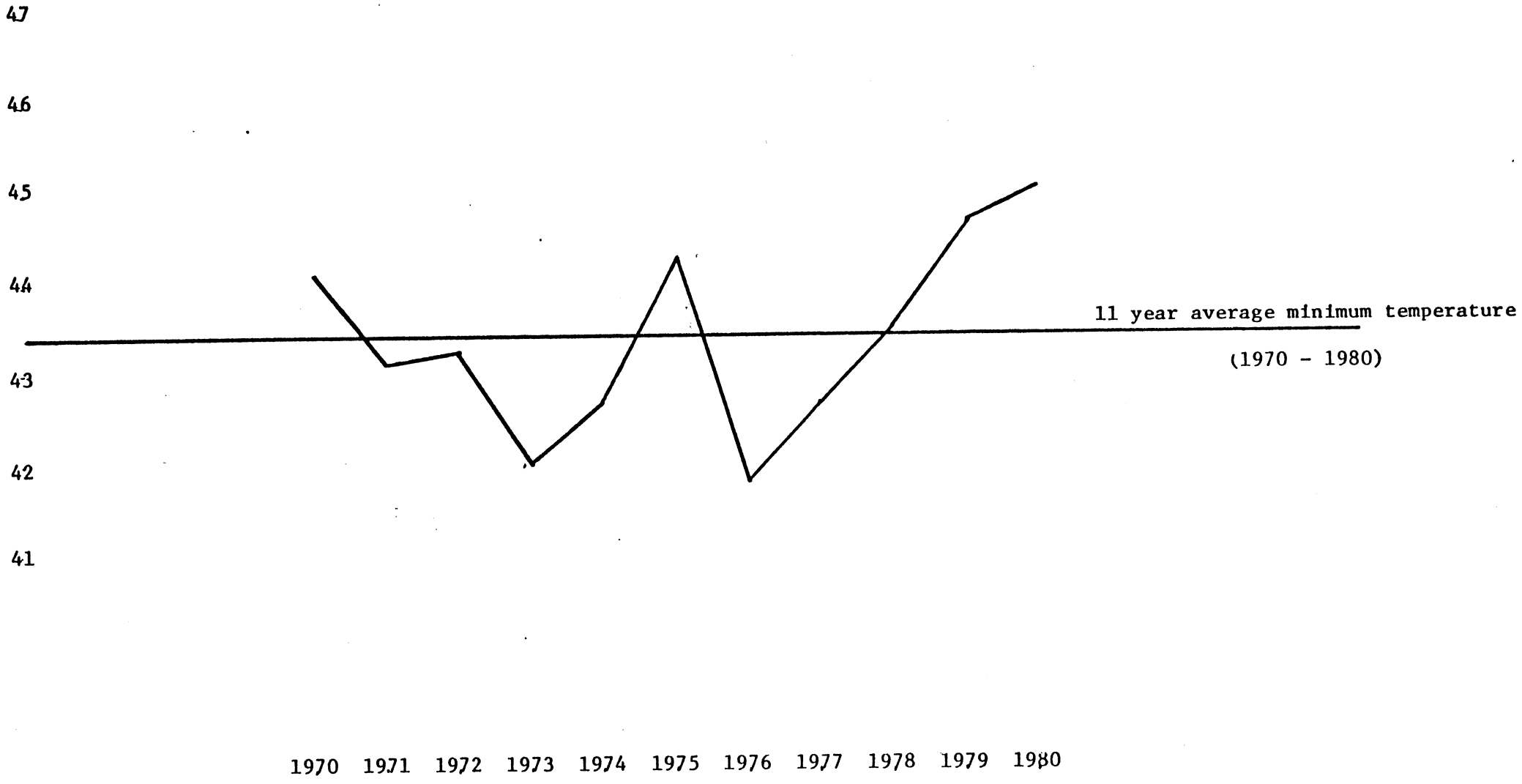
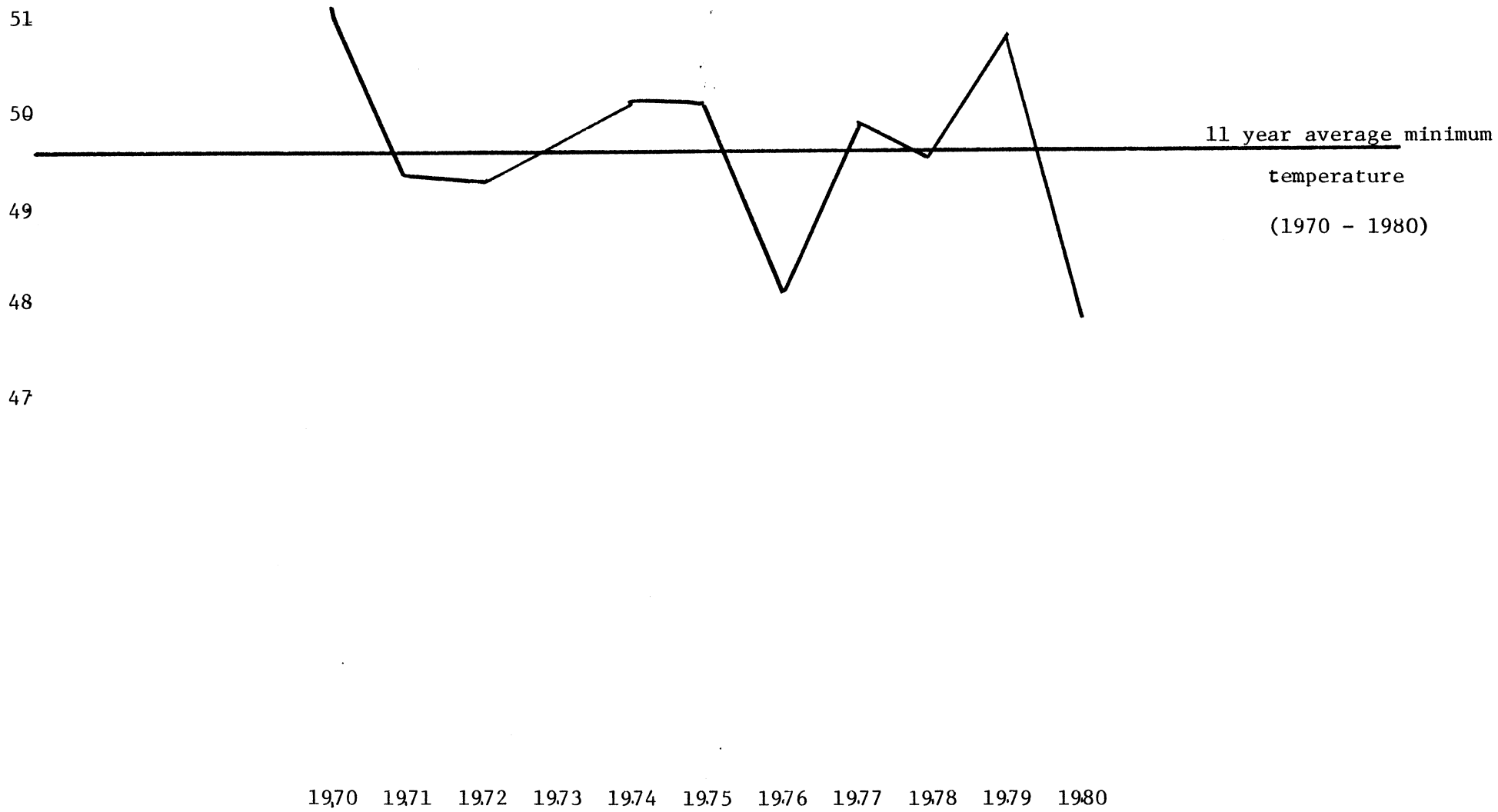


FIGURE 10.--AVERAGE MINIMUM TEMPERATURES

OKANOGAN, BIG BEND

(1970 - 1980)



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